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SILVICAL CHARACTERISTICS of DOUGLAS-FIR, var. menziesii

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SILVICAL CHARACTERISTICS OF DOUGLAS-FIR (VAR. MENZIESII)

by

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One of the world's most important and valuable timber trees, Douglas-fir (Pseudotsuga menziesii)[2/] ranges extensively throughout western North America. The typical variety, menziesii, attains better development and is of greater commercial value than the other recognized variety, glauca. More restricted in range than the species as a whole, the variety menziesii occurs west of the Cascade Range in Washington and Oregon, west of the Coast Range in British Columbia, and west of the Sierra Nevada in northern California (fig. 1). In north-south distribution, it extends from the central British Columbia coast (lat. 53°30' N.) to the central coast of California (lat. 36° N.) (13, 16).[3/]

Other names in general use are common Douglas-fir, Douglas-spruce, red fir, Oregon-pine, Coast Douglas-fir, and Oregon Douglas-fir (26). European nomenclature includes Douglas, Douglasii, and green Douglas.

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[2/] Scientific and common names of trees in this publication follow: Check list of native and naturalized trees of the United States (including Alaska) (26).

[3/] Underscored numbers in parentheses refer to Literature Cited.

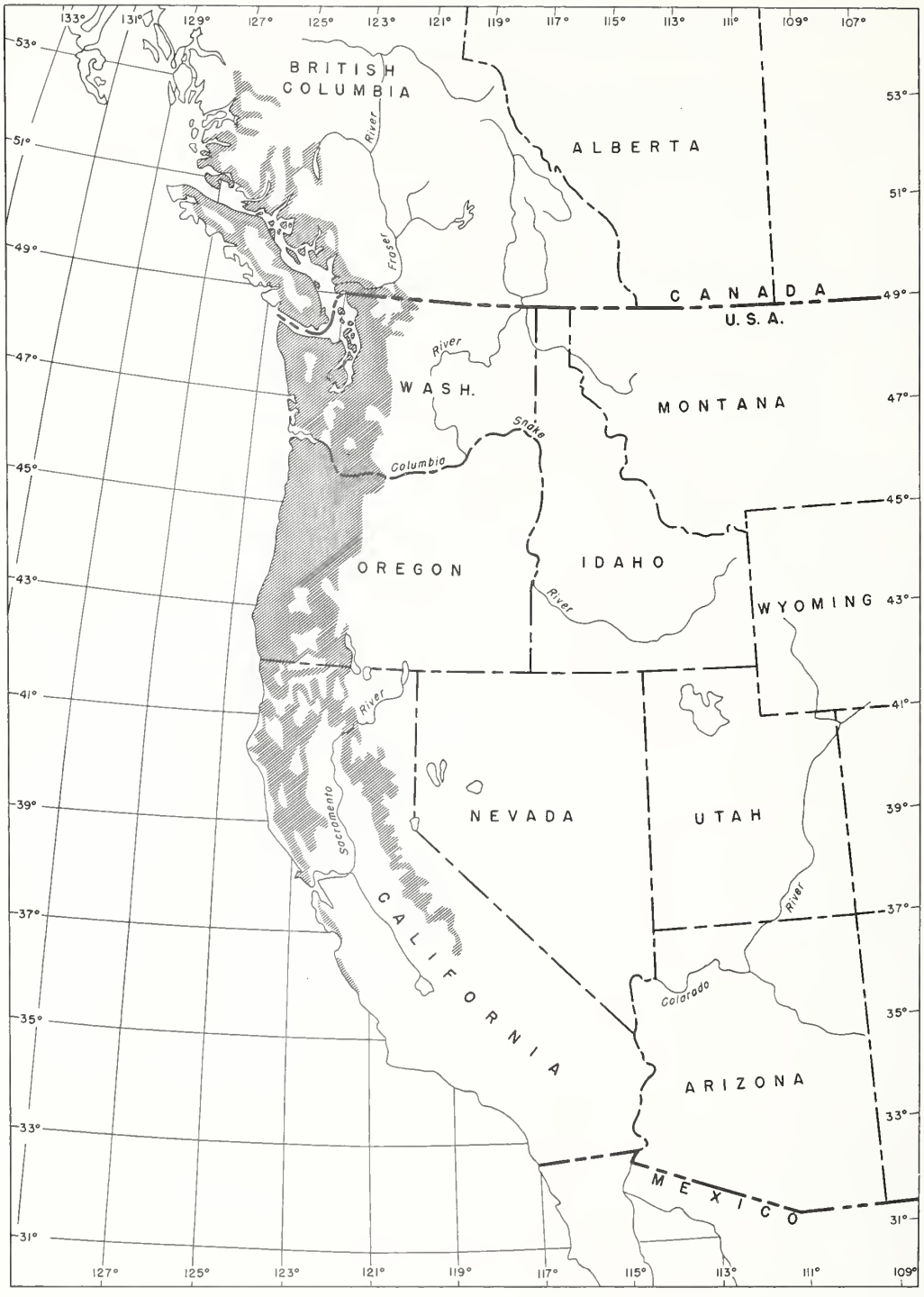

Figure 1.--Range of Douglas-fir (var. menziesii*).*

Principal wood uses, in approximate order of importance, are: structural timber, plywood, wood-fiber products, interior and exterior finish, poles, furniture, boats, and posts. A popular Christmas tree, Douglas-fir is widely cultivated for that purpose. Shelterbelt and ornamental plantings are also extensive.

HABITAT CONDITIONS

Climatic

The typical variety of Douglas-fir occurs in a mild and humid region with dry summers, and is a characteristic tree of Thornthwaite's superhumid and humid zones (39). Average annual temperature varies from 45° to 55° F., with an absolute maximum of about 110° and minimum of about 25° below zero. Weather data, mostly from lower elevations within the commercial range of Douglas-fir, describe an annual precipitation spread of 20 to 90 inches (40). The botanical range, however, extends to higher elevations, where the climate is colder and even more humid. Here, a large proportion of the winter precipitation occurs as snow that may accumulate to depths of 10 feet or more (42).

Edaphic

Douglas-fir grows in soils with a wide range in texture--varying from gravelly loam to clay loam (38). It occurs on acid soil types, which range in pH values from about 4.5 to 6.5. In western Oregon and western Washington, it reaches its best development on soils of the Melbourne, Olympic, and Astoria series at pH values from 5 to 5.5. Heaviest volumes, best development, and best stocking are usually found in deep loamy soil on well-drained benches or slopes with northerly exposures. Douglas-fir will not thrive on poorly drained soils or soils with an impervious layer near the surface. Between the Coast Range and the Pacific Ocean, soils are mostly sedimentary in origin, with volcanic rock intrusions; whereas from the Coast Range east to the summit of the Cascades, volcanic soil origin is the rule. Large areas of glacial-outwash soils are found around Puget Sound (38).

Physiographic

In the middle of its range (lat. 45° N.), the typical variety of Douglas-fir occurs from sea level to elevations as high as 5,000 feet. At latitude 50° N. on Vancouver Island, it is found up to the 4,000-foot elevation. At its extreme northern range in British Columbia, the upper altitudinal limit drops to about 2,700 feet. Southward, this limit increases to 6,000 feet at the northern boundary of California (lat. 42° N.). In the northern part of its range, Douglas-fir occurs mainly on southerly slopes; in the southern part, on northerly slopes and in moist canyon bottoms.

Biotic

Throughout the drier central part of its range, Douglas-fir occurs in vast, almost pure, even-aged stands. Farther south, it merges with ponderosa pine (Pinus ponderosa), sugar pine (Pinus lambertiana), incense-cedar (Libocedrus decurrens), and various oaks (Quercus spp.). Toward the northerly coastal limits of its range, Douglas-fir gives way to western hemlock (Tsuga heterophylla), western redcedar (Thuja plicata), and Sitka spruce (Picea sitchensis); whereas at higher elevations, true firs (Abies spp.) and mountain hemlock (Tsuga mertensiana) gradually replace it. The Society of American Foresters lists it as a component of 14 associations, including Type 229, the pure stand (35):

Type Number	Name
221 (subclimax)	Red Alder
223 (subclimax)	Sitka Spruce
224 (climax)	Western Hemlock
225 (climax)	Sitka Spruce—Western Hemlock
226 (climax)	Pacific Silver Fir—Hemlock
227 (climax)	Western Redcedar—Western Hemlock
228 (climax)	Western Redcedar
229 (subclimax)	Pacific Douglas-fir
230 (midphase)	Douglas-fir—Western Hemlock
231 (subclimax)	Port-Orford-cedar—Douglas-fir
232 (climax)	Redwood
233 (subclimax)	Oregon White Oak
234 (subclimax)[1/]	Oak—Madrone
244 (climax)	Pacific Ponderosa Pine—Douglas-fir

[1/] This type becomes climax south of the range of Douglas-fir and redwood.

The most important shrub species found in natural stands are salal (Gaultheria shallon),[4/] Oregongrape (Mahonia aquifolium), red whortleberry (Vaccinium parvifolium), box blueberry (V. ovatum), ovalleaf whortleberry (V. ovalifolium), salmonberry (Rubus spectabilis), western thimbleberry (R. parviflorus), and rhododendron (Rhododendron spp.). Vine maple (Acer circinatum), a small tree, occurs in shrub form throughout much of the range of Douglas-fir.

LIFE HISTORY

Seeding Habits

Flowering and fruiting.--The male and female cone buds form on the current season's growth in late summer but remain inconspicuous until they start swelling the following spring (1, 19). The pistillate buds occur just below the terminal bud; the staminate buds are farther down the stem. These reproductive buds (both sexes) burst in early April (fig. 2). The female strobili are then receptive

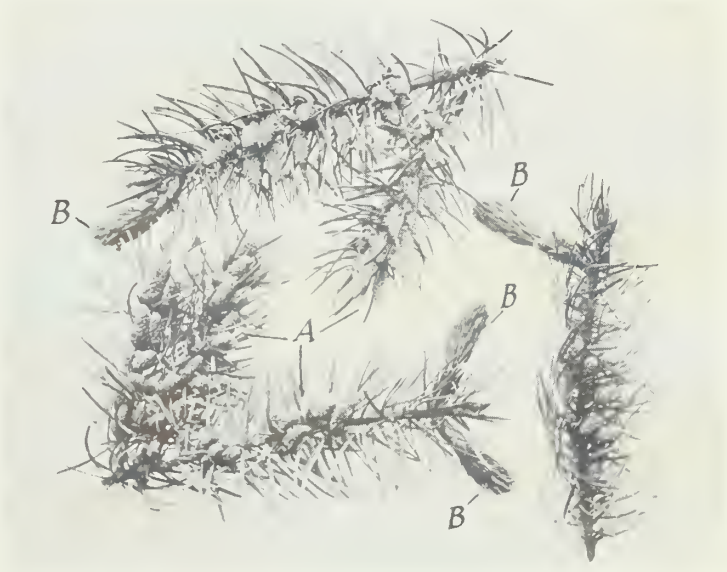

Figure 2.--Both staminate (A) and pistillate (B) strobili are commonly borne on the same twigs.

[4/] Scientific and common names of shrubs and herbs in this publication follow: Kelsey, Harlan P., and Dayton, William A. Standardized plant names. Ed. 2, 675 pp. Harrisburg, Pa. 1942.

to pollination almost immediately after emergence, and pollination takes place within about a 1-week period thereafter. Since the bursting dates of both staminate and pistillate buds are somewhat staggered, pollination may extend over a 3-week period within a forest stand (19). This is apparently a natural provision for promoting cross-pollination. Dichogamy is nevertheless not invariable, and male and female strobili may mature simultaneously on individual trees (2, 33). Actual fertilization of the female strobilus takes place about 2 months after pollination (1, 3, 4, 33), and the fertilized cones mature over one growing season. Male strobili wither and disappear shortly after pollen dissemination.

Records from 17 stations west of the Cascade Range in Washington and Oregon show the following chronology of events:5/

Event	Date
Pollen dissemination begins	April 21
Pollen dissemination ends	May 3
Vegetative buds burst	May 4
Cones begin to open	September 14

Seed is ripe in late August or early September, and dissemination may start about two weeks after ripening. The dispersal date, however, depends largely on the occurrence of dry weather to open the cones. Though height growth usually ceases in August--before seed dissemination begins--diameter growth may continue well into October (41).

Abnormal frosts may kill the young female cones and continuous rains sometimes hinder or prevent pollination. Otherwise, weather seems to have little direct effect on cone development (19, 33).

5/ Average day of year on which phenological development occurred in given species at points in Oregon and Washington. Dec. 9, 1952. (Unpublished data. On file U. S. Forest Serv. Pac. NW. Forest and Range Expt. Sta.)

Between flowering and seed shedding, a host of insects attack Douglas-fir cones and seeds. In addition, spruce budworm larvae sometimes attack both staminate and pistillate flowers while in bloom.[6/] Insects causing significant damage to Douglas-fir seed are (20): Douglas-fir seed chalcid (Megastigmus spermotrophus); Douglas-fir cone moth (Barbara colfaxiana); fir coneworm (Dioryctria abietella); fir cone looper (Eupithecia spermaphaga); and gall midges (Itonididae). Damage from insect attack is usually inversely proportional to abundance of cones, and most of the seed may be destroyed during years of light cone crops.

Animals (24, 30) are second only to insects in seed destruction. The Douglas squirrel (Tamiasciurus douglasii douglasii) and the Townsend chipmunk (Tamias townsendii) start clipping cones even before the seeds ripen. As soon as seed begins to fall, it is further subject to consumption by meadow mice (Microtus spp.), deer mice (Peromyscus maniculatus), and shrews (Sorex spp.).

Consumption of Douglas-fir seed by birds has not been measured, but seed is known to make up a considerable part of the diet of crossbills (Loxia spp.), winter wrens (Nannus spp.), and song sparrows (Melospiza spp.) during migration (11, 30).

During years of light or even medium cone crops, depredations by insects, rodents, and birds may reduce the amount of available seed to a seriously low level.

Seed production.--With few exceptions, Douglas-fir trees do not produce seed until they are at least 10 years old and about 15 feet tall (18). Open-grown trees begin producing seed in appreciable amounts between their 20th and 30th years, and maximum seed production occurs between the ages of 200 and 300 years. A mature open-grown tree will produce about a pound of seed per year (16, 19). Only part of the trees in a closed stand produce seed, however, and one such tree probably produces only about a tenth as much seed as an open-grown tree (12). On the average, heavy seed crops occur

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6/ Carolin, V. M. Studies of the biological control of the spruce budworm in Oregon. 1950. (Unpublished manuscript, Bureau of Entomology and Plant Quarantine, Forest Insect Investigation, New Haven, Conn.)

at 5- to 7-year intervals (19). Between heavy seed crops, at least one crop failure usually occurs in addition to two or more crops that are light or medium.

Seed dissemination. --Seed is mostly disseminated by wind (18). Small amounts are sometimes carried and buried by mice and chipmunks for a winter food supply. When not consumed, this seed may germinate and produce seedlings the following spring. Seed can be expected to spread from a timber edge--in quantities sufficient for rapid natural regeneration--about six tree lengths in the direction of favorable winds. Nevertheless, actual dissemination under field conditions is extremely variable. In some instances, areas over half a mile from a seed source have reseeded within a few years after cutting (7).

Vegetative Reproduction

Douglas-fir does not sprout from roots or stump. A lower limb left on a cut stump may turn up and, in time, form a new tree. This type of vegetative propagation, sometimes practiced by Christmas tree cutters, is rather limited. Douglas-fir cuttings have been successfully rooted in sand and other media, and treatment with hormones has generally improved rooting (15, 28). In genetics research or seed orchard establishment, cuttings have also been grafted onto Douglas-fir understock. However, methods for extensively propagating Douglas-fir vegetatively do not exist.

Seedling Development

Establishment. --Douglas-fir will germinate on almost any seedbed that provides adequate moisture and proper temperature. However, it germinates and develops best on a mineral soil surface (19, 31). Moisture requirements are high but the soil must be well drained.

Time of germination varies from season to season as well as with latitude and elevation. Germination starts as early as April 1 on warmer sites and as late as July 1 on colder sites. Once under way, germination may continue from 2 to 4 weeks (17). On good seedbeds, a large proportion of viable seed will normally germinate, but about three-fourths of the seedlings usually die during the first year or two. Major causes of seedling mortality are heat injury (to stem), drought, plant competition, frost, insects, disease (root rot and damping off),

and rodents (18, 19, 30). Surface soil temperatures over 125° F. may cause heat lesions on the stems of newly germinated seedlings (6).

From the Willamette Valley northward, clear cutting in either patches or strips usually favors rapid natural restocking of Douglas-fir. This cutting practice also facilitates broadcast burning of slash and exposure of mineral soil as a seedbed. Regeneration is generally most successful on shaded northerly aspects. On southerly exposures, some shade is essential to protect newly germinated seedlings from heat injury.

Early growth.--New seedlings need light shade but once established thrive best in full sunlight. Plant cover heavier than 25 percent may be progressively harmful. In the seedling stage, shoot and diameter growth usually continue for 3 to 4 months after buds burst. Though slow at first, annual height growth of seedlings increases steadily until it reaches a fairly uniform rate at 6 to 10 years. In one example, average total height of the 25 percent tallest juvenile trees on freshly burned soil, medium site III, was (18):

Age of seedlings (Years)	Total height (Inches)
1	2.0
3	5.3
5	15.8
7	32.6
9	55.9

Sapling Stage to Maturity

Growth and yield.--Natural stands of Douglas-fir normally start with more than a thousand trees to the acre, and stand density remains characteristically high during the course of development (fig. 3). The process of natural thinning begins early in dense stands as suppressed trees are shaded out and die. Yields per acre and size of average tree in fully stocked stands at 100 years of age are shown in table 1.

Douglas-fir shares with several of its associates the ability to maintain a fairly rapid rate of height growth over a very long

Figure 3.--Young-growth stand of Douglas-fir on a good site.

period of years. On a medium site (III), height growth, which averages more than 2 feet annually at age 20, continues at a rate of 0.5 feet per year at age 100 and 0.3 feet at age 120 (27).

Reaction to competition.--When rated alongside all other commercial conifers in the West, Douglas-fir is classified as intermediate in tolerance to shade (5). When compared with only its most common associates, however, Douglas-fir ranks very high on the scale of intolerance. For satisfactory establishment and development, it requires more light than western hemlock, western redcedar, Sitka spruce, grand fir (Abies grandis), mountain hemlock, or Pacific silver fir (Abies amabilis)--its most common associates in the northern part of its range. It likewise requires more light than redwood (Sequoia sempervirens), white fir (Abies concolor), incense-cedar, or Port-Orford-cedar (Chamaecyparis lawsoniana)--species with which it often intermingles in southwestern Oregon or northern California. Douglas-fir rates about equal in tolerance with sugar pine,

Table 1.--Stand yields and dimensions of average tree in fully stocked stands of Douglas-fir at 100 years of age, by site class (27)

Site class[1]	Average stand per acre, when trees are--				Average tree (7 inches & larger)		
	7 inches d.b.h. & larger		12 inches d.b.h. & larger				
	Total trees	Volume (International)[2]	Total trees	Volume (Scribner)	D.b.h.	Total height[3]	Volume
	Number	Board-feet	Number	Board-feet	Inches	Feet	Cubic feet
I	75	148,900	75	115,100	27.6	200	255
III	182	94,700	145	62,800	16.9	140	73
V	301	28,800	78	9,600	10.5	80	17

[1] Using the recognized site quality classification for Douglas-fir, in which site I is the most productive and site V the least productive.

[2] 1/8-inch rule.

[3] Average total height of dominants and codominants only. Total height of tree of average diameter would be less.

western white pine (Pinus monticola), and California red fir (Abies magnifica). Only three common associates of Douglas-fir--ponderosa pine, Jeffrey pine (Pinus jeffreyi), and noble fir (Abies procera)--are rated as less tolerant, or more light-demanding.

Because Douglas-fir almost always occurs in associations that contain more tolerant trees, it rarely maintains a climax position and is generally recognized as a subclimax species. Its widespread occurrence in extensive even-aged stands is attributed largely to stand destruction by periodic fires, clear cutting, insect attack, or a combination of these factors. If stands were protected indefinitely from these drastic disturbances, Douglas-fir would gradually be replaced throughout much of its range by the more tolerant hemlock, cedar, and true fir (32). Some limited areas of the ponderosa pine—Douglas-fir type in southern Oregon and northern California may represent an exception to this general rule.

When Douglas-fir develops in a closed stand, the lower limbs lose vigor and die rapidly as they are subjected to increasing overhead shade. Nevertheless, natural pruning is exceedingly slow because even small dead limbs resist decay and persist for a very long period. On the average, Douglas-fir is not clear to a height of 17 feet until 77 years old, and to 33 feet until 107 years (22). Obviously, artificial pruning must be employed if clear butt logs are to be produced during cutting rotations of less than 150 years.

Young seedlings and saplings of Douglas-fir respond satisfactorily to release from competing brush or overstory trees if they have not been suppressed too severely or too long. Trees of pole and small sawtimber size also respond well to conservative thinning--the dominants often showing the most pronounced response (37). Douglas-firs that have developed in a closed stand are poorly adapted to radical release--such as that occasioned by very heavy thinning. When exposed, the long slender boles with short crowns are highly susceptible to damage from snowbreak, windfall, and sunscald. Recent evidence shows that sudden and drastic release of young Douglas-firs may cause a sharp reduction in height growth (36).

Damaging agents. -- During development from the sapling to maturity, Douglas-fir is subject to serious damage from a variety of agents. High winds following heavy rainfall may cause widespread losses from windthrow (14, 34). Heavy snows and glaze storms periodically break out the tops of scattered trees in dense young

stands (29). Crown fires, when they occur, destroy stands of all ages. The thick bark of older Douglas-firs, however, makes them fairly resistant to ground fires.

The Douglas-fir beetle (Dendroctonus pseudotsugae) attacks trees from the large pole stage to maturity, killing trees in patches on extensive areas during epidemics. Outbreaks characteristically develop in windthrown and fire-killed timber and sometimes around felled timber. The flatheaded fir borer (Melanophila drummondi) causes similar but less extensive killing.

A large number of trunk and root rots cause losses of merchantable volume in old-growth stands. The most serious heartwood decays in young-growth Douglas-fir are caused by Fomes pini, which is especially virulent in the southern part of the tree's range, and Polyporus schweinitzii. Fomes subroseus causes another common heart rot in young-growth Douglas-fir. It usually gains entrance through broken tops and is especially abundant in "sleet belts." A killing root disease, Poria weirii, is currently recognized as the most serious fungus enemy of Douglas-fir (8). It attacks trees of all ages and causes continuing mortality in young-growth stands of both pole and sawtimber size. Poria weirii and Polyporus schweinitzii cause death of old trees by contributing to uprootal or breakage near the ground.

Two kinds of animal damage have given concern in some localities. Saplings are sometimes deformed by deer from browsing or from horn rubbing; bear sometimes deform and even kill young trees by stripping off the bark and cambium (9).

SPECIAL FEATURES

Douglas-fir bark contains from 25 to 50 percent cork (21). Percentage of cork varies with the age of the tree and is concentrated in the zone near the ground. This fraction is now being separated by one company and put to commercial use. Douglas-fir bark also contains about 30 percent extractives, such as wax, tannin, and dihydroquercetin (23).

RACES AND HYBRIDS

In addition to the menziesii form of Douglas-fir, botanists recognize the glauca variety, which occurs on the east slopes of the Cascade Range and Sierra Nevada and in the Rocky Mountains (10,

25, 26). Known variously as blue Douglas-fir, Colorado Douglas-fir, or Rocky Mountain Douglas-fir, this variety differs from menziesii in foliage color, cone form, and growth rate, as well as in environmental requirements. Though it is quite possible that other varieties exist, authorities do not universally agree beyond the menziesii-glauca separation.

Even within the range of the typical form, Douglas-fir has become adapted to many different combinations of climate and soil and cannot be moved indiscriminately from low to high elevations, or from southern to northern latitudes (16).

No hybrids of Douglas-fir, either natural or developed through controlled pollination, are known to exist.

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